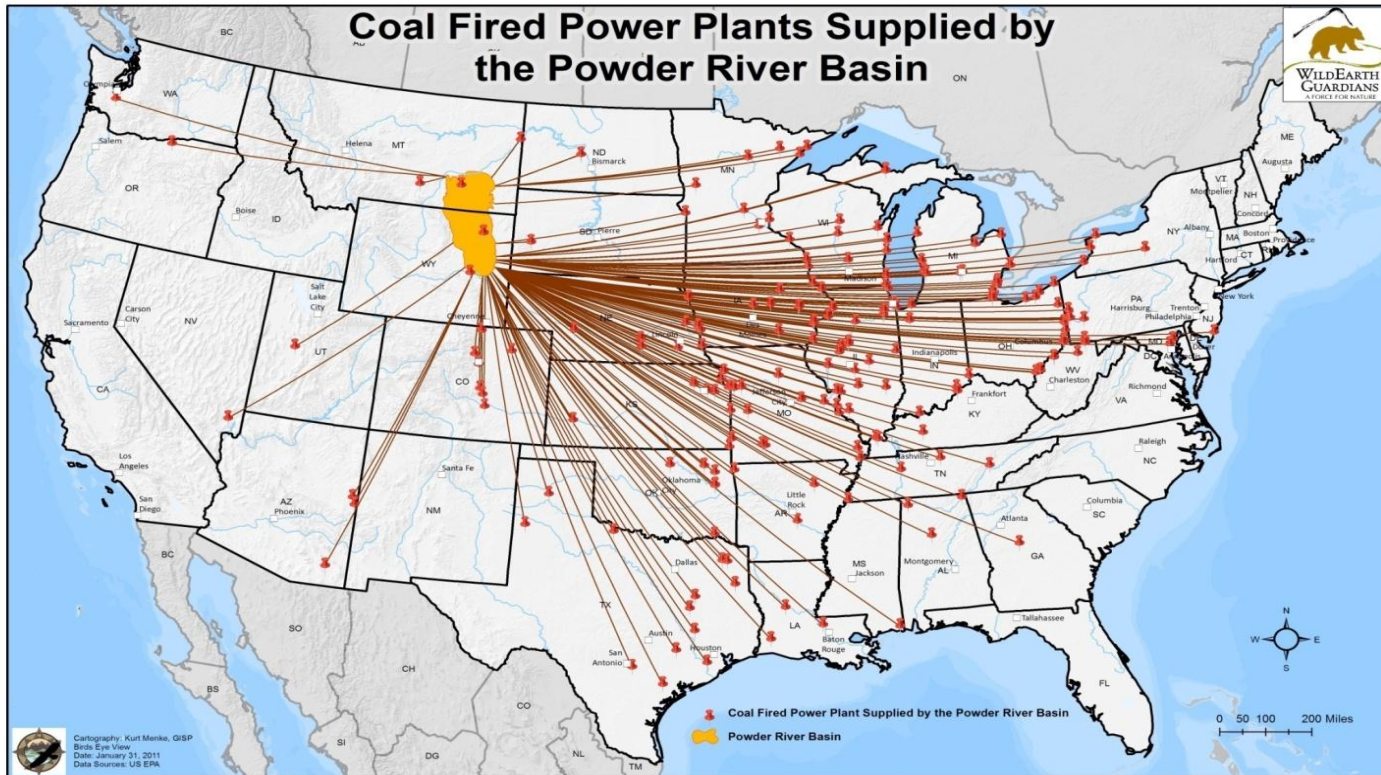# Public Health Impacts of Coal Exports

**Robert K. Merchant, M.D., FCCP**

**Pulmonary Specialist**

**Billings Clinic**

May 10th, 2013

# Powder River Basin Coal



Coal Fired Power Plants Supplied by the Powder River Basin

In 2009, 42% of the nation's coal came from the Powder River Basin

99% of this coal was used in the US

# U.S. Coal Markets Declining

Coal consumption has declined >20% since 2000

No new power
  plants built

Transition to
  natural gas

Renewable/
  sustainable
  energy use



Colstrip Power Plant, MT

# Growing Demand in Asia

Growth in Asian coal demand is expected to dramatically increase by 2030.

US Energy Information Agency predicts that nearly 90% of that increased use will be in China.



Beijing, China

# Predicted Increases in Coal Export

Recent PRB coal export shipments: 3 and 6 million tons/year

Based on coal company projections, PRB coal exports are expected to increase to:

– 75 million tons/year by 2017

– 170 million tons/year by 2022

# 75 million tons of coal = 30 additional trains/day going through Montana
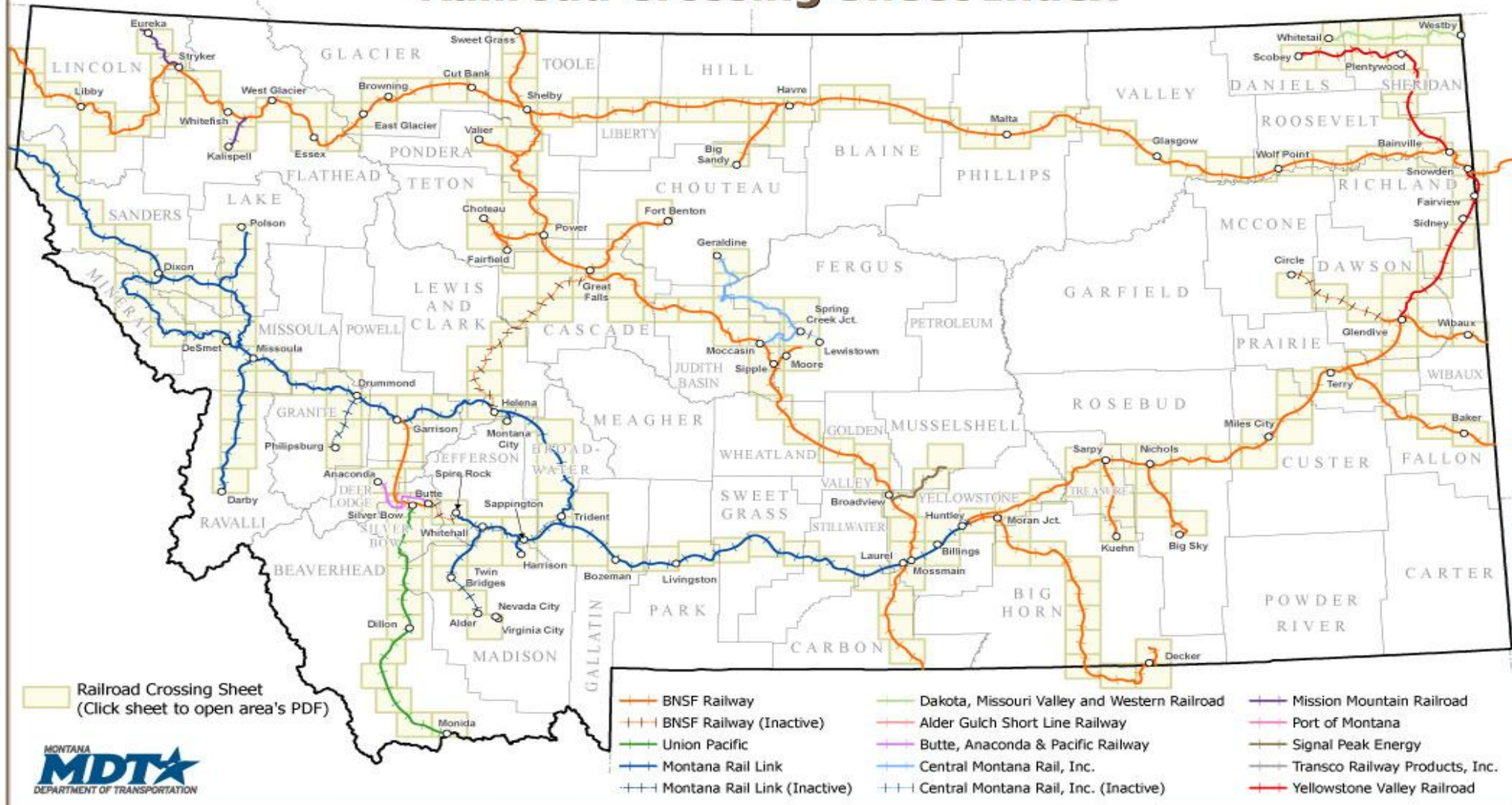


15 full trains going West

- 120 – 125 cars/train
- 115 tons of coal/car
- 14,000 tons of coal/train

15 empty trains going East

170 million tons of coal = 64 additional trains/day

# Railroad Crossing Sheet Index

| | |
|---|---|
| Railroad Crossing Sheet (Click sheet to open area's PDF) | |

— BNSF Railway
+—+ BNSF Railway (Inactive)
— Union Pacific
— Montana Rail Link
+—+ Montana Rail Link (Inactive)

— Dakota, Missouri Valley and Western Railroad
— Alder Gulch Short Line Railway
— Butte, Anaconda & Pacific Railway
— Central Montana Rail, Inc.
+—+ Central Montana Rail, Inc. (Inactive)

— Mission Mountain Railroad
— Port of Montana
— Signal Peak Energy
— Transco Railway Products, Inc.
— Yellowstone Valley Railroad

MONTANA
MDT★
DEPARTMENT OF TRANSPORTATION

# Why worry?

- People's health will be adversely affected
  - Asthma
  - COPD
  - CVAs and MIs
  - HTN
  - Lung Cancer

- Economics
  - Health effects represent a "negative externality" to the coal industry
  - Disease prevention through environmental intervention is cost saving

# The Cost-Effectiveness of Environmental Approaches to Disease Prevention



Chokshi, NEJM. 2012; 367: 295
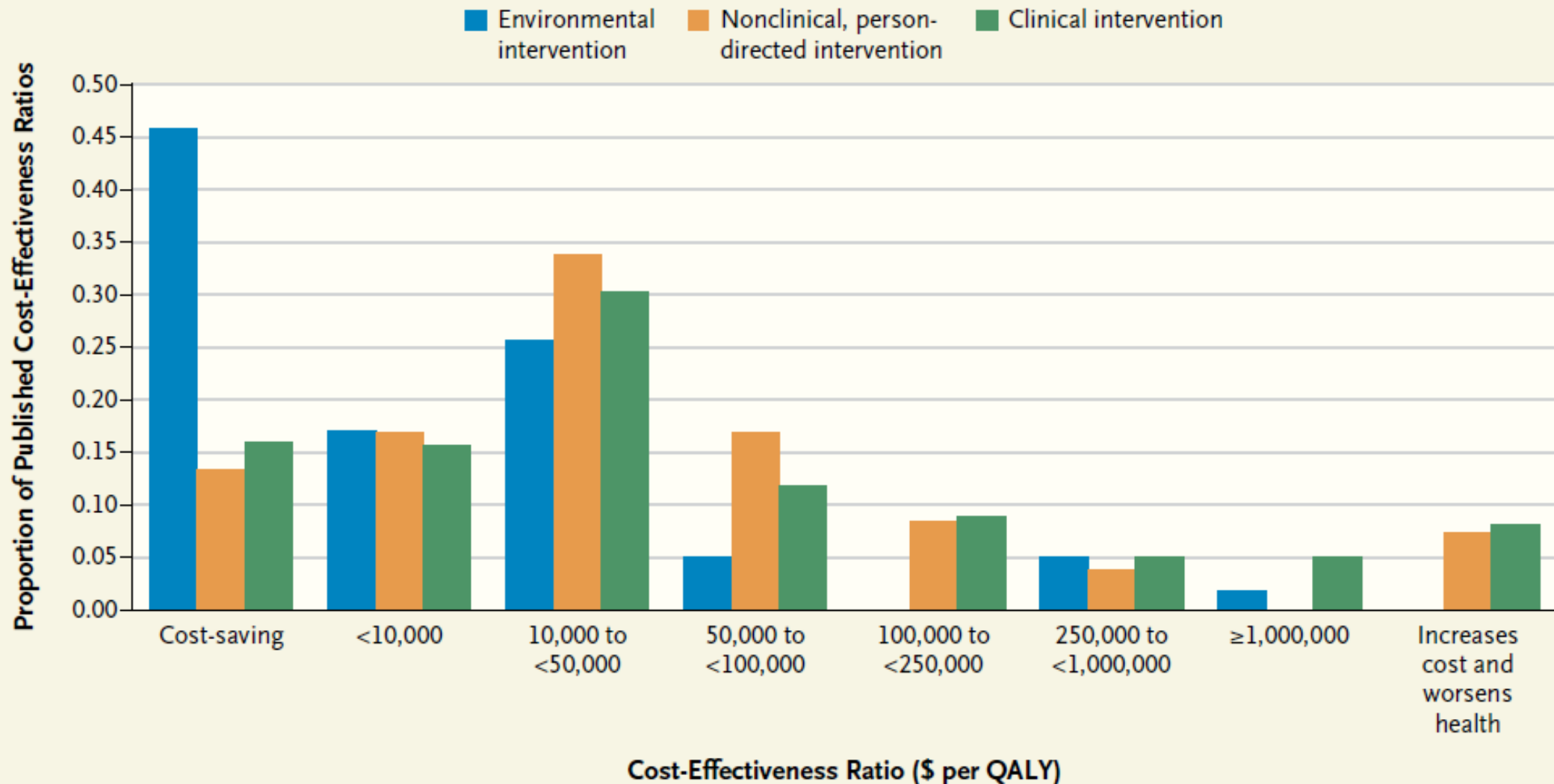
# Clean Air Act Amendments of 1990

Benefits
($2 trillion)

Costs
($65 billion)
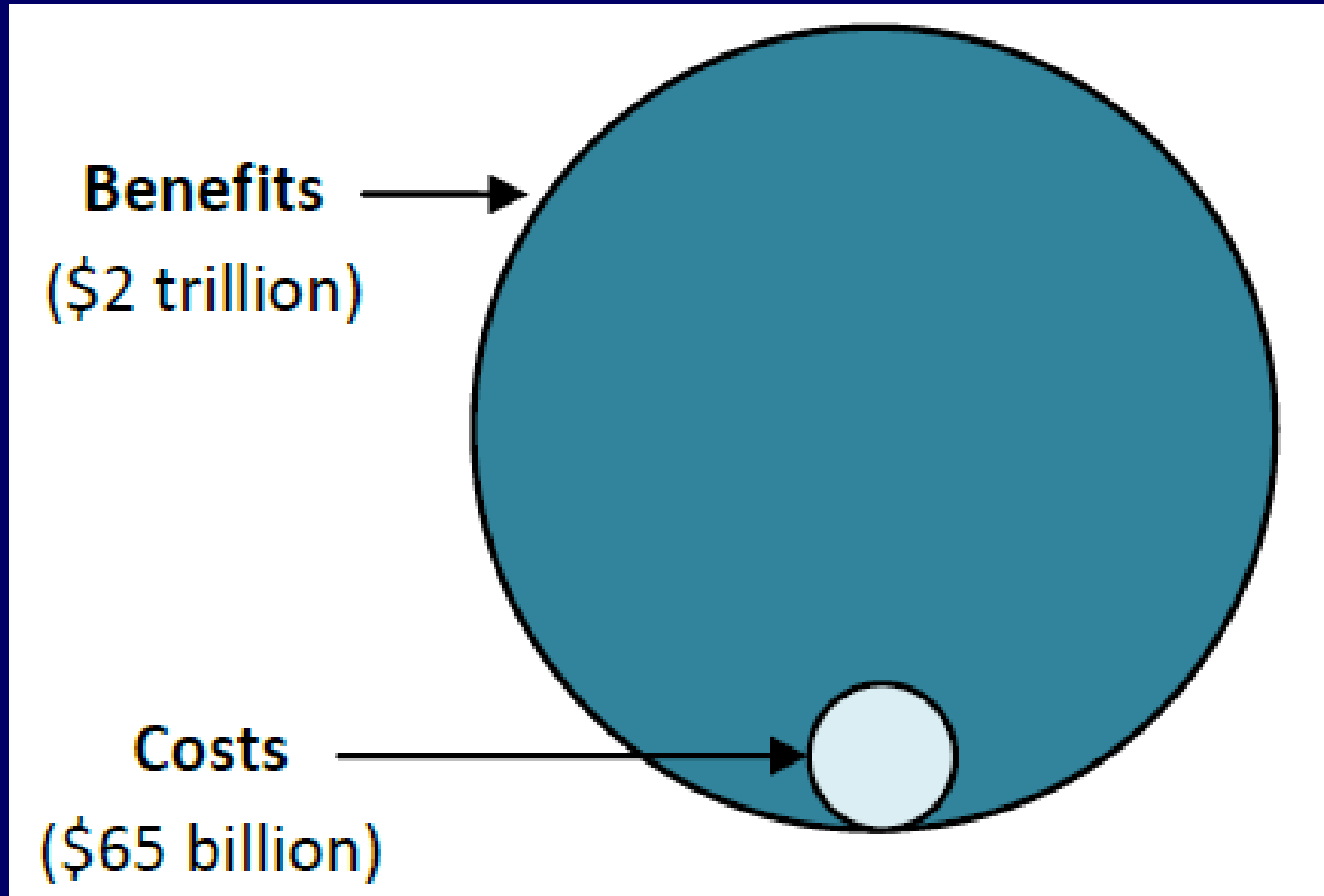
# Sources of Impact from Coal Trains

- Diesel Exhaust
- Coal dust
- Noise
- Global Climate Change

# Sources of Impact

- Diesel Exhaust
  - PM 2.5
  - Nitrogen Oxides (NOx)
  - Ozone
  - Benzene
  - Very fine particles absorb organics onto their surface and carry these deep into the lung
- Coal Dust
  - PM 2.5
  - Carbon
- Noise
  - dB
- Climate change
  - Temperature, growing season, precipitation, CO2 levels

# Health Effects

- Causes Asthma
- Exacerbations of Asthma and COPD
- Vascular Disease
  - MI
  - CVA
  - Cognitive decline
- Hypertension
- Cancer

# Traffic-related Air Pollution and the Development of Asthma and Allergies during the First 8 Years of Life

- Prospective birth cohort study with 8 yr follow-up of 3863 children.
- Determined individual  exposures to
    - Particulate matter (PM2.5)
    - Nitrogen Dioxide (NO2)
    - Soot
  - Land use regression model
- Yearly questionnaires  Sxs, Diagnoses.
- Compared odds ratio of interquartile range increase in pollutants
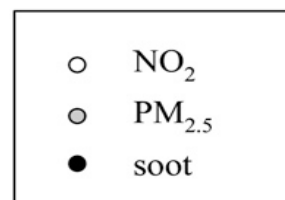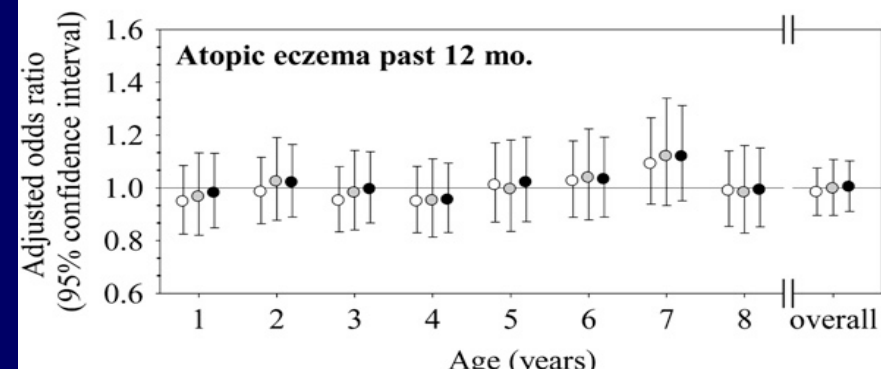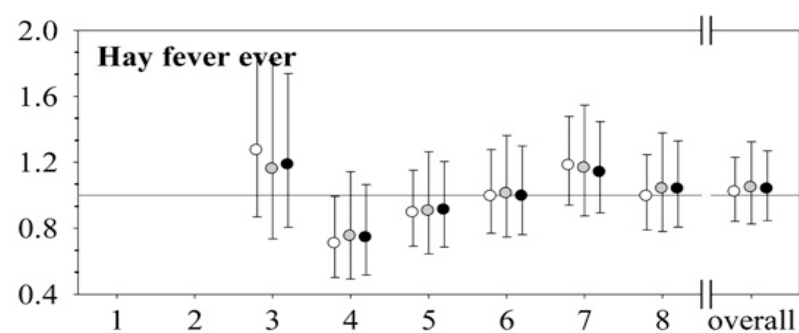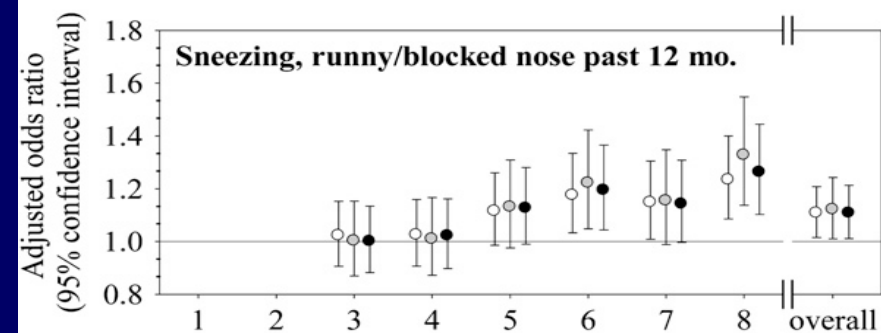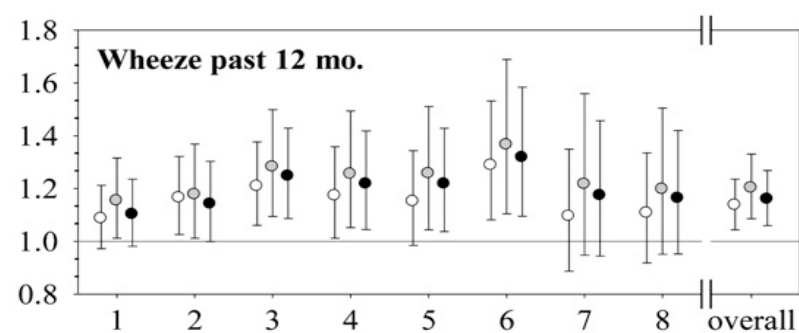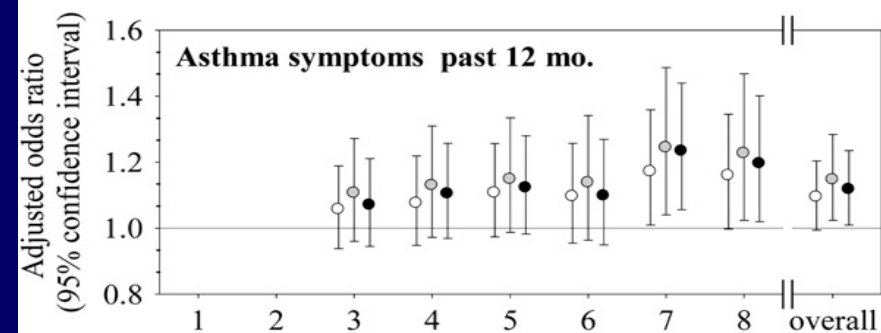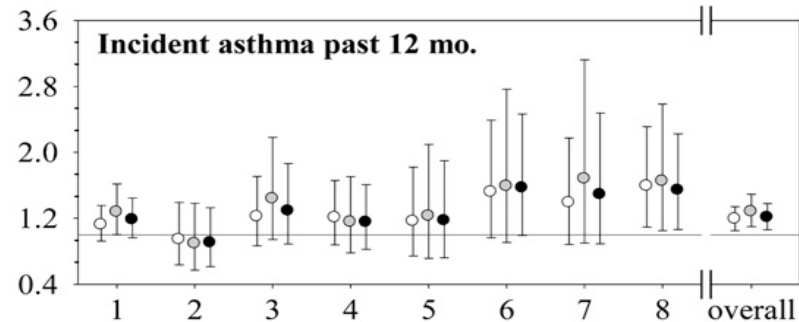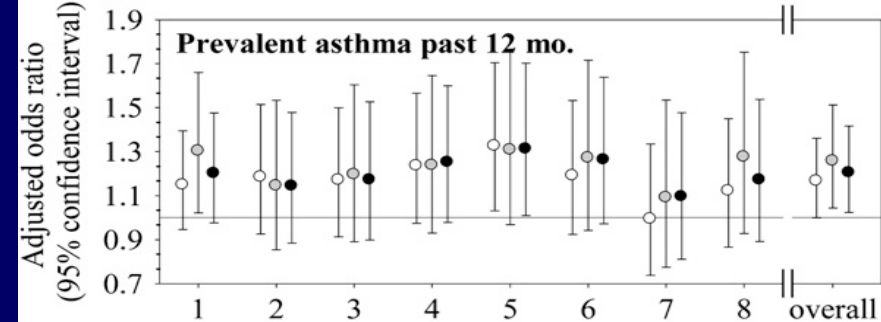
Gehring, AJRCCM. 2010; 181: 596

# Traffic-related Air Pollution and the Development of Asthma and Allergies during the First 8 Years of Life

TABLE 5. ADJUSTED ASSOCIATIONS* BETWEEN PM$_{2.5}$ LEVELS AT BIRTH ADDRESS AND HEALTH OUTCOMES FOR CHILDREN WHO DID AND CHILDREN WHO DID NOT MOVE HOUSE DURING THEIR FIRST 8 YEARS OF LIFE

| | Nonmovers | | | Movers | | |
|---|---|---|---|---|---|---|
| | n† | OR | 95% CI | n† | OR | 95% CI |
| During the first 8 years of life | | | | | | |
| Prevalent asthma | 1,575‡ | 1.34 | 1.03–1.75 | 1,605‡ | 1.19 | 0.92–1.53 |
| Incident asthma | 1,551‡ | 1.36 | 1.09–1.69 | 1,588‡ | 1.20 | 0.98–1.48 |
| Asthma symptoms | 1,556‡ | 1.27 | 1.07–1.49 | 1,596‡ | 1.05 | 0.90–1.23 |
| Wheeze | 1,575‡ | 1.25 | 1.08–1.45 | 1,605‡ | 1.15 | 1.00–1.32 |
| Sneezing, runny/blocked nose | 1,556‡ | 1.14 | 0.98–1.34 | 1,596‡ | 1.09 | 0.95–1.25 |
| Hay fever | 1,556‡ | 1.43 | 1.01–2.04 | 1,596‡ | 0.81 | 0.58–1.12 |
| Atopic eczema | 1,575‡ | 1.03 | 0.89–1.21 | 1,605‡ | 0.97 | 0.84–1.12 |
| At age 8 years | | | | | | |
| Bronchial hyperresponsiveness | 464 | 0.99 | 0.69–1.41 | 351 | 0.96 | 0.69–1.34 |
| Allergic sensitization | 617 | 1.25 | 0.96–1.61 | 881 | 1.07 | 0.83–1.39 |

# Traffic-related Air Pollution and the Development of Asthma and Allergies during the First 8 Years of Life

- OR of 1.28 for developing asthma for interquartile range increase in traffic related air pollution

Gehring, AJRCCM. 2010; 181: 596

# Short-term Associations between Ambient Air Pollutants and Pediatric Asthma Emergency Department Visits

- Compared pediatric ER visits for asthma or wheezing with ambient levels of ozone and traffic related pollutants
  - 41 Atlanta ERs with 91,386 visits
  - 3 day moving average of pollutant level preceding ER
  - 1993-2004
- Case crossover analysis using Poisson generalized linear models

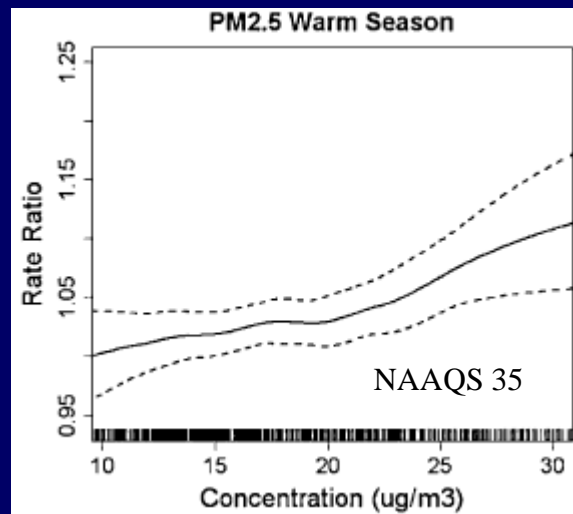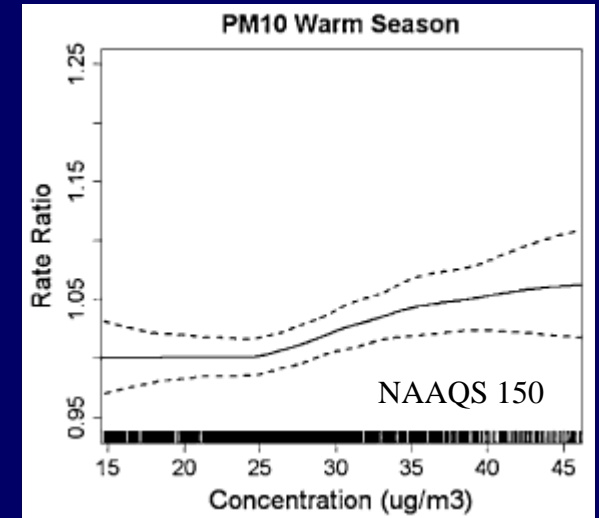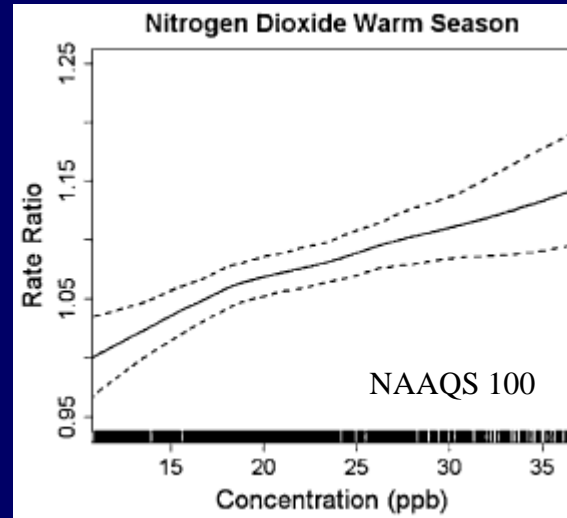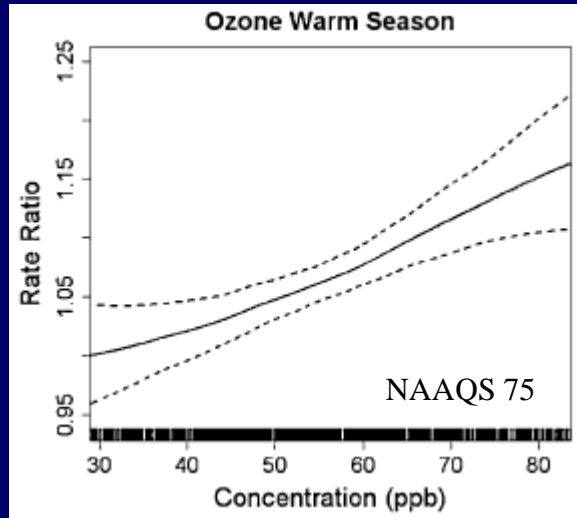# Short-term Associations between Ambient Air Pollutants and Pediatric Asthma Emergency Department Visits

TABLE 2. RATE RATIOS AND 95% CONFIDENCE INTERVALS FROM POISSON GENERALIZED LINEAR MODELS FOR INTERQUARTILE RANGE INCREASES IN THREE-DAY MOVING AVERAGE POPULATION-WEIGHTED AMBIENT AIR POLLUTANT CONCENTRATIONS*

| | Overall RR (95% CI) (Jan–Dec) | Warm Season RR (95% CI) (May–Oct) | Cold Season RR (95% CI) (Nov–Apr) |
|---|---|---|---|
| Ozone[†‡] | 1.062 (1.031–1.093) | 1.082 (1.043–1.123) | 1.044 (0.992–1.098) |
| Nitrogen dioxide[†] | 1.036 (1.018–1.055) | 1.066 (1.038–1.095) | 1.016 (0.992–1.040) |
| Carbon monoxide[†] | 1.023 (1.006–1.041) | 1.068 (1.034–1.102) | 1.005 (0.985–1.025) |
| Sulfur dioxide[†] | 1.012 (0.994–1.030) | 1.030 (1.002–1.058) | 1.001 (0.978–1.025) |
| $PM_{10}$[§] | 1.020 (1.003–1.038) | 1.026 (1.001–1.051) | 1.018 (0.994–1.043) |
| $PM_{10-2.5}$[‖] | 1.034 (1.011–1.057) | 1.025 (0.991–1.059) | 1.041 (1.010–1.073) |
| $PM_{2.5}$[‖] | 1.020 (1.002–1.039) | 1.043 (1.016–1.070) | 1.005 (0.978–1.031) |
| $PM_{2.5}$ sulfate[‖] | 1.014 (0.995–1.033) | 1.027 (1.004–1.049) | 0.991 (0.953–1.029) |
| $PM_{2.5}$ elemental carbon[‖] | 1.015 (0.997–1.033) | 1.041 (1.010–1.072) | 1.003 (0.981–1.026) |
| $PM_{2.5}$ organic carbon[‖] | 1.008 (0.994–1.021) | 1.034 (1.007–1.062) | 1.000 (0.985–1.016) |
| $PM_{2.5}$ water-soluble metals[‖] | 1.021 (1.000–1.042) | 1.029 (1.003–1.055) | 1.005 (0.968–1.043) |

Strickland, AJRCCM. 2010; 182: 307

# Short-term Associations between Ambient Air Pollutants and Pediatric Asthma Emergency Department Visits
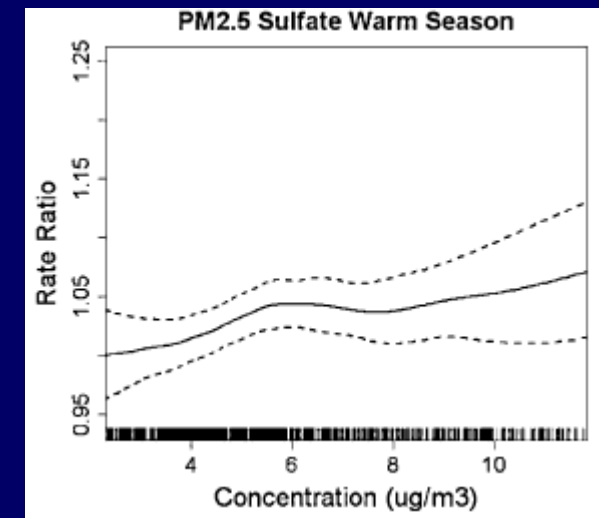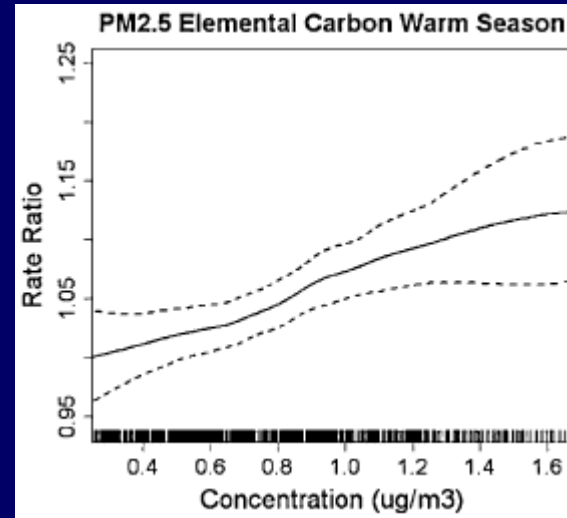
# Short-term Associations between Ambient Air Pollutants and Pediatric Asthma Emergency Department Visits

- Traffic related pollutants increase ER visits for asthma in children.
  - Occurred at exposures significantly below current standards

# Recent warming by latitude associated with increased length of ragweed pollen season in central North America

**Table 1.** Change in length (day of year, days) of ragweed pollen season as a function of latitude for National Allergy Bureau and Aerobiology Research Laboratories sites along a south–north latitudinal gradient

| Location | Latitude | Years of data | Start 1995 | End 1995 | Start 2009 | End 2009 | Change |
|---|---|---|---|---|---|---|---|
| Georgetown, TX | 30.63°N | 17 | 198 ± 7 | 320 ± 7 | 195 ± 7 | 313 ± 7 | −4 d |
| Oklahoma City, OK | 35.47°N | 19 | 212 ± 7 | 300 ± 10 | 227 ± 9 | 316 ± 15 | +1 d |
| Rogers, AR | 36.33°N | 15 | 231 ± 7 | 295 ± 8 | 227 ± 6 | 296 ± 8 | −3 d |
| Papillion, NE | 41.15°N | 21 | 212 ± 3 | 281 ± 6 | 208 ± 4 | 288 ± 10 | +11 d |
| Madison, WI | 43.00°N | 27 | 208 ± 2 | 272 ± 4 | 205 ± 3 | 281 ± 6 | +12 d |
| LaCrosse, WI | 43.80°N | 22 | 213 ± 3 | 271 ± 3 | 205 ± 5 | 276 ± 5 | +13 d* |
| Minneapolis, MN | 45.00°N | 19 | 208 ± 5 | 270 ± 6 | 206 ± 7 | 284 ± 7 | +16 d* |
| Fargo, ND | 46.88°N | 15 | 216 ± 4 | 252 ± 8 | 217 ± 4 | 269 ± 8 | +16 d* |
| Winnipeg, MB, Canada | 50.07°N | 16 | 207 ± 7 | 264 ± 6 | 197 ± 7 | 279 ± 7 | +25 d* |
| Saskatoon, SK, Canada | 52.07°N | 16 | 206 ± 12 | 250 ± 6 | 197 ± 13 | 268 ± 7 | +27 d* |

Years represent the number of years for which pollen data were available. Regression analysis was used to determine the "best-fit" line for all years for a given location. This analysis was then used to determine the start and end day of each year (±95% confidence interval) for the duration of the ragweed pollen season in 1995 and again in 2009.
*Significant increase in the length (days) of the ragweed pollen season.

# Recent warming by latitude associated with increased length of ragweed pollen season in central North America
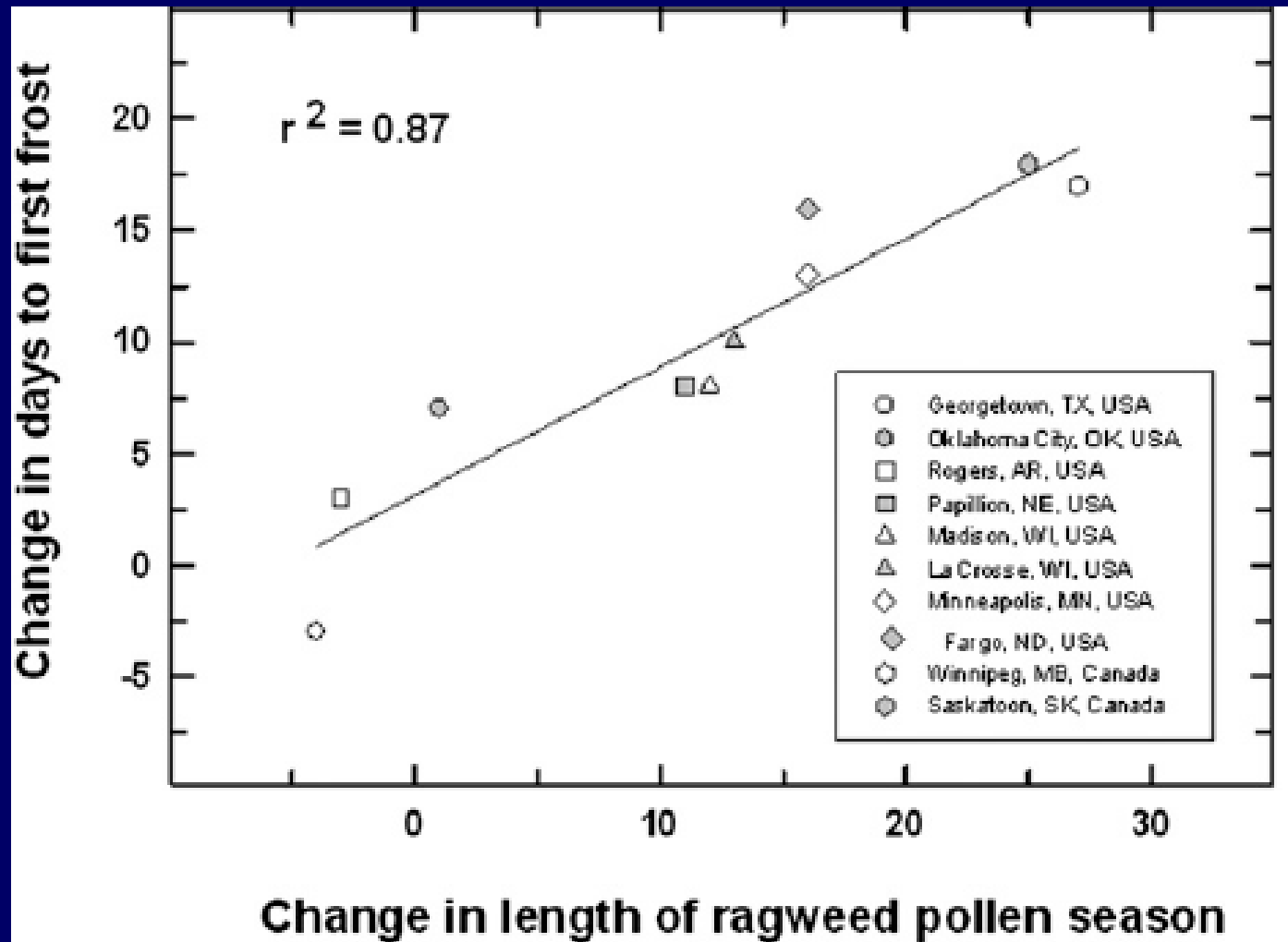
## Ambient Air Pollution and the Risk of Acute Ischemic Stroke

- Evaluated the association between PM 2.5 and ischemic stroke
  - Time stratified case-crossover design
  - 1763 consecutive neurologist confirmed ischemic strokes admitted to BIDMC 1999 to 2008
  - During this time Boston was "in attainment"
  - Hourly levels of PM 2.5 in the time preceding CVA
    - Excluded days when the air quality was poor (but still in attainment)

# Ambient Air Pollution and the Risk of Acute Ischemic Stroke
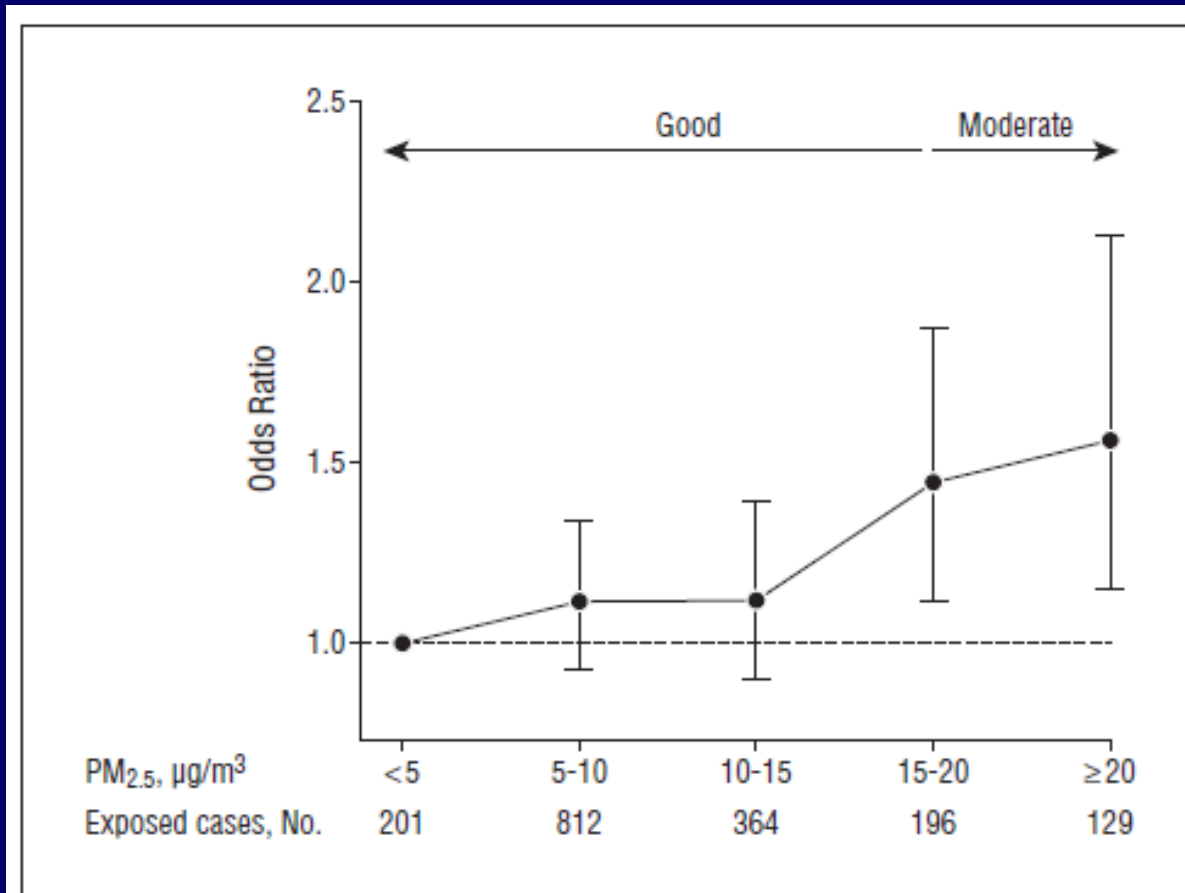


**Figure 1.** Odds ratio of ischemic stroke onset for US Environmental Protection Agency categories (*good* and *moderate*) of mean ambient fine particulate matter air pollution ($PM_{2.5}$) levels in the 24 hours preceding stroke onset. Error bars indicate 95% CIs.

# Ambient Air Pollution and the Risk of Acute Ischemic Stroke
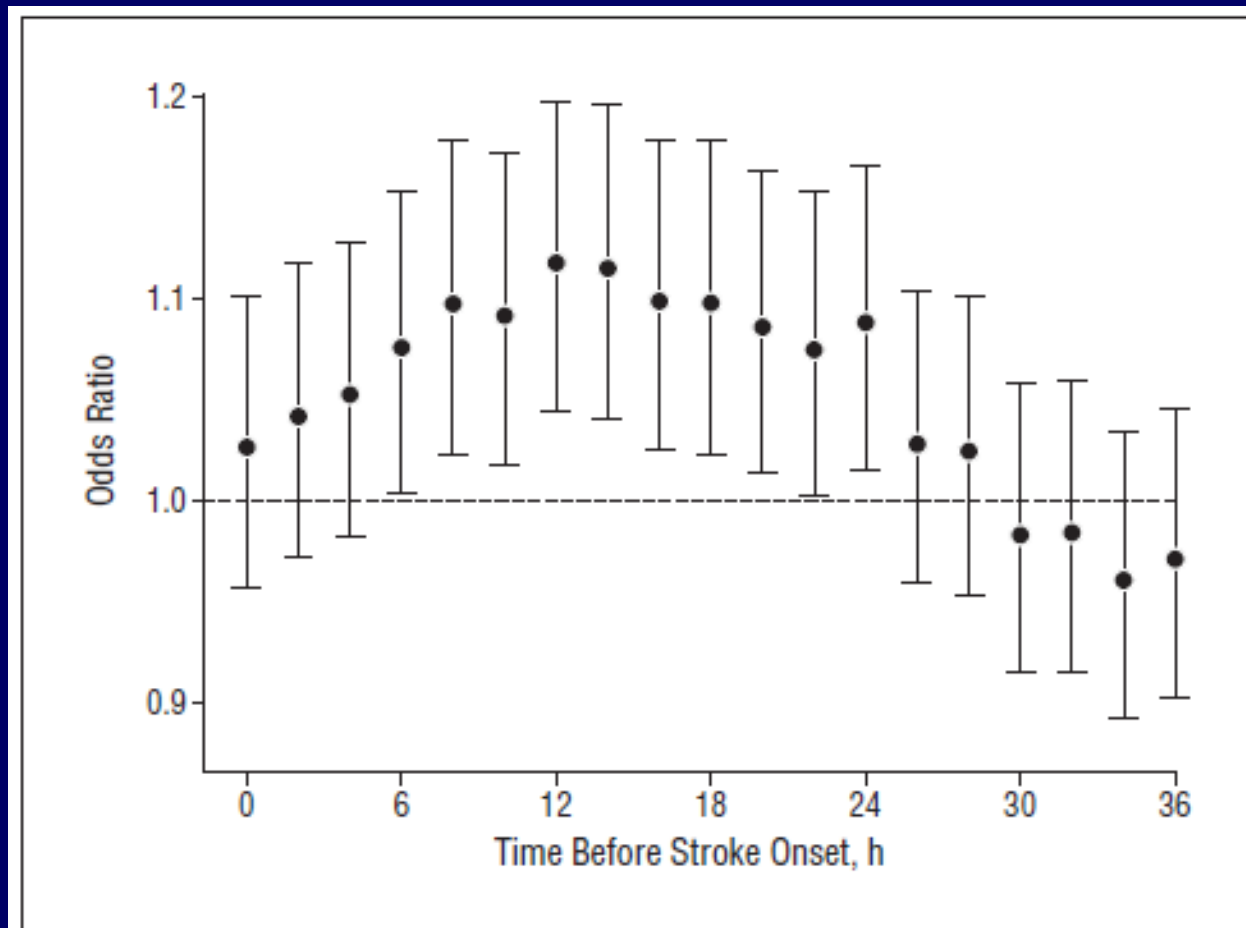


**Figure 2.** Odds ratio of ischemic stroke onset per interquartile range increase in concentration of ambient fine particulate matter air pollution (6.4 μg/m³) in the hours preceding stroke onset. Error bars indicate 95% CIs.

Wellenius, Arch Intern Med. 2012; 172: 229

# Ambient Air Pollution and the Risk of Acute Ischemic Stroke

- Ischemic strokes are strongly associated with increased PM 2.5 exposures well within the national standards
  - 34% increase in risk of stoke for moderate vs mild exposures peaking 12 hours after the exposure.

Wellenius, Arch Intern Med. 2012; 172: 229

# Exposure to road traffic and railway noise and associations with blood pressure and self-reported hypertension: a cohort study

- Prior studies linking traffic and railway noise did not control for air pollutants.

- 57,053 enrolled
  - Baseline:  BP and health survey
  - 5-7 yr follow-up:  health survey
  - Modeled traffic and railway noise and NOx exposure
    - Day, evening and night

Sorensen, Env Health. 2011; 10: 92

# Exposure to road traffic and railway noise and associations with blood pressure and selfreported hypertension: a cohort study

- Traffic noise – 0.26 mmHg increase in SBP
- Railway noise > 60 dB – 8% increase in developing HTN

Sorensen, Env Health. 2011; 10: 92

# The Diesel Exhaust in Miners Study: A Nested Case–Control Study of Lung Cancer and Diesel Exhaust

- Nested case control study in a cohort of 12315 non-metal miners, 8 facilities
  - 198 Lung Cancer deaths
  - 562 Matched controls
- Exposures to "respirable elemental carbon" modeled from detailed occupational history
- Adjusted for smoking and other potential confounders

# The Diesel Exhaust in Miners Study

**Table 3.** Odds ratios (ORs) and 95% confidence intervals (CIs) for average and cumulative REC and total duration REC exposure*

| Exposure metric | Case subjects | Control subjects | OR (95% CI) | $P_{trend}$ |
|---|---|---|---|---|
| Average REC intensity, quartiles, unlagged, µg/m³ | | | | |
| 0 to <1 | 49† | 166 | 1.0 (referent) | .025 |
| 1 to <32 | 50 | 207 | 1.03 (0.50 to 2.09) | |
| 32 to <98 | 49 | 145 | 1.88 (0.76 to 4.66) | |
| ≥98 | 50 | 148 | 2.40 (0.89 to 6.47) | |
| Quartiles, lagged 15 y, µg/m³ | | | | |
| 0 to <1 | 47† | 190 | 1.0 (referent) | .062 |
| 1 to <6 | 52 | 187 | 1.11 (0.59 to 2.07) | |
| 6 to <57 | 49 | 141 | 1.90 (0.90 to 3.99) | |
| ≥57 | 50 | 148 | 2.28 (1.07 to 4.87) | |
| Cumulative REC, quartiles, unlagged, µg/m³-y | | | | |
| 0 to <19 | 49 | 151 | 1.0 (referent) | .083 |
| 19 to <246 | 50 | 214 | 0.87 (0.48 to 1.59) | |
| 246 to <964 | 49 | 147 | 1.50 (0.67 to 3.36) | |
| ≥964 | 50 | 154 | 1.75 (0.77 to 3.97) | |
| Quartiles, lagged 15 y, µg/m³-y | | | | |
| 0 to <3 | 49 | 158 | 1.0 (referent) | .001 |
| 3 to <72 | 50 | 228 | 0.74 (0.40 to 1.38) | |
| 72 to <536 | 49 | 157 | 1.54 (0.74 to 3.20) | |
| ≥536 | 50 | 123 | 2.83 (1.28 to 6.26) | |
| Duration of REC exposure, y | | | | |
| Unexposed‡ | 48 | 165 | 1.0 (referent) | .043 |
| 0 to <5 | 51 | 169 | 1.16 (0.53 to 2.55) | |
| 5 to <10 | 20 | 95 | 0.88 (0.38 to 2.03) | |
| 10 to <15 | 31 | 107 | 0.93 (0.39 to 2.21) | |
| ≥15 | 48 | 130 | 2.09 (0.89 to 4.90) | |

# The Diesel Exhaust in Miners Study: A Nested Case–Control Study of Lung Cancer and Diesel Exhaust

| Smoking intensity (packs per day) | Cumulative REC lagged 15 years OR (95% CI), No. of case subjects/No. of control subjects | | |
| --- | --- | --- | --- |
| | Tertile 1, 0 to < 8 µg/m³-y | Tertile 2, 8 to < 304 µg/m³-y | Tertile 3, ≥304 µg/m³-y |
| Never smoker | 1.0 (referent), 3/59 | 1.47 (0.29 to 7.50), 4/74 | 7.30 (1.46 to 36.57), 7/45 |
| <1 | 6.25 (1.42 to 27.60), 10/41 | 7.42 (1.62 to 34.00), 10/49 | 16.35 (3.45 to 77.63), 15/39 |
| 1 to <2 | 10.16 (2.55 to 40.53), 29/78 | 11.58 (2.87 to 46.71), 32/86 | 20.42 (4.52 to 92.36), 27/63 |
| ≥2 | 26.79 (6.15 to 116.63), 19/22 | 22.17 (4.84 to 101.65), 15/22 | 17.38 (3.48 to 86.73), 10/28 |
| Unknown† | 4.13 (0.74 to 23.22), 4/25 | 3.79 (0.64 to 22.41), 4/23 | 27.85 (5.03 to 154.31), 9/12 |

# The Diesel Exhaust in Miners Study: A Nested Case–Control Study of Lung Cancer and Diesel Exhaust

- 2.83 fold increase in lung cancer from diesel exposures (highest vs lowest quartile)
- 7.30 fold increase in lung cancer in the non-smokers
- Harm was seen at levels analogous to those found in many cities

# Variability

- type of train
- Proximity
- Time
- Weather
- individual susceptibility
- Age of train (2008 EPA standards)

# Conclusions

- Increased train traffic will increase
  - Asthma problems,
  - MI CVA
  - Cancer
  - By how much is unknown
- The problems will be greatest for those living or working near the railways
- The problems with lessen  over the next 20 years due to 2008 EPA locomotive standards.
- But will not go away

# References

- Chokshi, The Cost-Effectiveness of Environmental Approaches to Disease Prevention. NEJM, 2012; 367: 295

- Gehring, Traffic-related Air Pollution and the Development of Asthma and Allergies during the First 8 Years of Life, AJRCCM. 2010; 181: 596

- Sorensen, Exposure to road traffic and railway noise and associations with blood pressure and selfreported hypertension: a cohort study, Env Health. 2011; 10: 92

- Silverman, The Diesel Exhaust in Miners Study: A Nested Case–Control Study of Lung Cancer and Diesel Exhaust, J Natl Cancer Inst. 2012; 104: 1

- Strickland, Short-term Associations between Ambient Air Pollutants and Pediatric Asthma Emergency Department Visits, AJRCCM. 2010; 182: 307

- Wellenius, Ambient Air Pollution and the Risk of Acute Ischemic Stroke, Arch Intern Med. 2012; 172: 229

- Ziska, Recent warming by latitude associated with increased length of ragweed pollen season in central North America. PNAS, 2011; 108 (10): 4248.

- http://www.epa.gov/oar/sect812/prospective2.html